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RESULTS OF A SURVEY TO DETERMINE FELEX PRIORITIES

by

Jay Adamsson

MARCH 1998

OTTAWA, CANADA

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ABSTRACT

Canada's Maritime Forces are pursuing a Frigate Equipment Life Extension (FELEX) program, the intent of which is to maintain the capabilities of the City class frigates in the face of advancing threat technology. Maritime Operational Research was tasked to assist in deciding which potential upgrades should be pursued. A survey was conducted among senior naval officers to determine the relative priorities of upgrading ship capability in various warfare areas. Through the survey, it was determined that Air and Surface warfare capability have the highest upgrade priority, followed by Subsurface capability. Ship capability in the Mine and Shore warfare areas were given a much lower priority.

RÉSUMÉ

Les Forces maritimes canadiennes ont entrepris un programme d'extension de la durée de vie des frégates (FELEX) de la classe Cité pour les préparer à affronter les menaces posées par les technologies de pointe les plus récentes. Le groupe de Recherches Opérationnelles maritimes a été chargé de déterminer les améliorations potentielles de la capacité des navires sur lesquelles il convient de se concentrer. Le groupe a mené une enquête auprès d'officiers supérieurs dans divers secteurs de conduite de la guerre. Il ressort de cette enquête qui'il faut tout d'abord améliorer les capacitées de combat anti-aérien at naval, puis la capacité de lutte anti-sous-marine La priorité la plus faible revient à l'amélioration des capacitées de minage et de défense côtière.

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RESULTS OF A SURVEY TO DETERMINE FELEX PRIORITIES

INTRODUCTION

1. To maintain capabilities for the Halifax class frigates, a Frigate Equipment Life Extension (FELEX) program is being prepared. Faced with a vast array of potential upgrades, Director General Maritime Doctrine and Operations (DGMDO) tasked Operational Research to investigate the impact of various updates on the capability of the Halifax class frigates.

2. This study will be conducted in a number of phases. First, five warfare areas have been identified: Air, Surface, Subsurface, Mine, and Shore. The importance of upgrading ship capabilities in each of these areas is determined through the use of a survey, the results of which are presented in this report. Secondly, the applicability of each upgrade to each warfare area is determined. Cost estimates are then incorporated into the equation to determine a set of candidate equipment upgrades. Finally, the best candidates for upgrade are analyzed further to confirm their utility and feasibility. This report provides the result of the first step of this process: the survey used to determine upgrade priorities.

3. The procedure outlined relies heavily upon expert opinion. This is unavoidable in that threats are being forecasted 10-15 years into the future, and many of the technologies under consideration have not been fully developed yet. As a result, the challenge is to incorporate intelligence and projections concerning future developments into a structured model. The first phase of the procedure, prioritization of warfare areas for upgrade, used a survey process. Later aspects of this study will combine additional expert opinions with intelligence projections, performance measurements, costs, and more stringent analysis to determine upgrade effects on ship capability.

SURVEY METHODOLOGY

Overview

4. To give an overall measure to the effects of equipment modifications, three levels of consensus and/or measurement must be determined. First is a determination of the importance of upgrading the level of performance of the frigate in performing various tasks. In this study, a task refers to an area of warfare involving the frigates that can be quantified. These tasks will be used to measure changes in the effectiveness of the frigates due to equipment modifications. These tasks will then be related to a number of scenarios. These scenarios are representative situations that the frigates are prepared to encounter, and are used to decide the relative importance of each task. A list of the tasks and scenarios used in this study can be found in Annex A. Secondly, the list of possible upgrades will be prioritized, using the results of the first phase along with expert opinion, cost, and engineering information. Third is to conduct a more thorough analysis of those upgrades which were ranked highest.

5. This note reports the results of the first phase of the process. This phase of the study was conducted in two steps. First, a survey was used to provide an initial weighting of upgrade importance. Next, a discussion was held with the survey participants where the results from the survey were modified as appropriate.

6. This note also provides an initial summary of the potential FELEX upgrades and cost estimates. This information will be used in the second phase to prioritize FELEX upgrade candidates.

Consensus Weighting Procedure

7. The aim of the consensus procedure is to describe the importance of upgrading the ability of a frigate to perform each task. This is accomplished by producing a weighting of the tasks.

Each warfare area will be assigned a percentage, or weight, all of which add up to 100%. The tasks within each warfare area are then weighted similarly. The percentage associated with each task describes the relative importance of upgrading the ability to perform this task in relation to all other tasks.

8. Obtaining a consensus on the relative importance of each task requires a gathering of naval experience and expertise. A survey was used to obtain an initial weighting of warfare area and task importance for each scenario (see Annex B). The results of this survey are used to compile an initial weighting using the Analytic Hierarchy Process (AHP, Ref 1). An overview of the mathematics of this procedure is given in Annex C. Once the initial results are compiled, all involved participants meet to discuss areas of difference, and adjust their weightings as desired. The product of this procedure is a list of weights for the various tasks in relation to each scenario. The weights achieved through this procedure are given in Tables I and II. This weighting gives the relative importance of upgrading the ability of the frigates in accomplishing each task, and is used in the ensuing facets of the study.

9. Six scenarios were used for this study. They are described in more detail in Annex B, and are summarized as:

a. Scenario 4. Countering smugglers off the coast of Canada.

b. Scenario 6. Peace support operations leading to the establishment of a naval embargo.

c. Scenario 8. Dispute over mineral deposits just outside 200 NM limit.

d. Scenario 9. Peace support operations. Conflict between two states has resulted in a UN decision to restore ante bellum status quo.

e. Scenario 10. Defence of Canadian/US territory.

f. Scenario 11. Collective defence of a NATO nation.

10. The survey in Annex B was sent out to fourteen naval officers of rank Commander and above. A limited sample was chosen for two reasons. First, a similar survey had recently been

carried out by Operational Research, and it was felt that another wide ranging survey would risk "survey burnout" by the participants. Secondly, the procedure being followed for the determination of weights called for the participants to gather and reevaluate the responses. This was only feasible with a small, local group of respondents. The participants chosen were all based in Ottawa, and have had significant operational experience and varied backgrounds. Nine responses were received, and the replies were converted into weights through the AHP.

11. The weights deduced from the survey responses were used as a beginning value for upgrade importance. Following the survey, a meeting was held in which nine of the survey participants, or their representatives, participated. The purpose of the meeting was to present the survey results, and seek confirmation of the produced weights. At this meeting, the participants were provided with a list and weights. Each scenario was considered in turn, the survey results discussed, and the participants were asked if they agreed with the results. Of the six scenarios, the participants agreed with the initial survey results for three, and felt that three others should be modified. The weights for these three scenarios were modified manually (not through the AHP process), and a new weighting was produced with which all participants agreed. The resulting weights are given in Table I and II below.

TABLE I

WARFARE AREA WEIGHTS

	Scenario					
	4	**6**	**8**	**9**	**10**	**11**
Air	31%	26%	30%	30%	21%	29%
Subsurface	10%	17%	28%	26%	32%	25%
Surface	44%	35%	33%	18%	23%	21%
Mines	4%	14%	6%	15%	20%	17%
Shore	11%	8%	3%	11%	4%	8%

TABLE II

WARFARE TASK WEIGHTS

	Scenario					
	4	6	8	9	10	11
Air						
Detect/Track	18%	10%	11%	8%	11%	8%
Identify	11%	11%	13%	12%	6%	12%
Counter	2%	5%	6%	10%	4%	9%
Subsurface						
Detect/Classify	4%	6%	10%	7%	9%	7%
Localize/Track	3%	4%	8%	6%	9%	6%
Destroy	1%	3%	4%	5%	4%	5%
Counter	2%	4%	6%	8%	10%	7%
Surface						
Detect/Track	24%	16%	14%	5%	10%	7%
Identify	17%	15%	13%	7%	8%	8%
Destroy	3%	4%	6%	6%	5%	6%
Mines						
Detect	4%	14%	6%	15%	20%	17%
Shore						
Detect	9%	5%	2%	7%	3%	5%
Engage	2%	3%	1%	4%	1%	3%

UPGRADE CANDIDATES

12. Table III provides a list of potential upgrades and cost estimates. The provided costs are estimates as of Oct 96, and include both equipment and installation. Costs preceded with an asterisk include equipment cost only. A definition of the listed abbreviations is given in Annex D. Also included in this table is an indication of which warfare area each upgrade would impact. The list and costs provided are preliminary and are subject to change.

TABLE III

POTENTIAL FELEX UPGRADES

Equipment	Estimated Cost	Air	Surface	Subsurface	Mine	Shore
Guns	$100m	✔	✔			✔
CIWS (Phalanx)	$40m	✔				
CIWS (RAM)	* $120m	✔				
ESSM	* $150m	✔				
Area AAW Missile	* $140m	✔				
Harpoon Block 2 / Block 2000 Upgrade	$35m		✔			
PGM		✔	✔			✔
STIR	$152m (8 ships)	✔	✔			
Medium-range Surface Radar	$72m	✔	✔			
3D Radar	$100m (4 ships)	✔	✔			

Equipment	Estimated Cost	Air	Surface	Subsurface	Mine	Shore
2D Radar	$96m	✔	✔			
APAR	$460m (4 ships)	✔	✔			
NULKA	$60m	✔				
SIERA	$84m	✔	✔	✔		✔
ELINT	$75m	✔	✔			✔
SIRIUS	$145m	✔	✔			✔
Laser Warning Receiver	$10m	✔	✔			
CEC	$100m	✔	✔	✔		✔
Shipborne HFSWR	$100m	✔	✔			✔
IASWSS	$360m			✔	✔	
Ship Signature Reduction	$100m	✔	✔	✔	✔	✔

DISCUSSION

13. As can be seen in Table I, the main emphasis is usually in the warfare areas of Air and Surface, with Subsurface also rating highly. The remaining two areas, Mines and Shore, are given much lower levels of importance. One notable exception is for scenario 10 (defence of North America) in which Subsurface was rated much more highly than the other areas.

14. The numbers given for warfare tasks were derived from the survey alone. There was insufficient time during the reevaluation meeting to consider these numbers any further. However, they give an indication of which singular aspect of the warfare area needs to be

improved. A review of these numbers in Table II reveals that, in most instances, the emphasis lies in upgrading the ability to detect and/or track a threat.

15. The upgrade information given in Table III summarizes the cost of each upgrade, and the warfare areas on which each upgrade will impact. This information provides a starting point for phase 2 of the process. The next step is to identify the upgrades which will have the greatest impact on each warfare area. Taking costs into account, the top candidates for upgrades will then be identified.

REFERENCES

1. Saaty, Thomas L., "The Analytic Hierarchy Process", RWS Publications, 1990.

ANNEX A
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TASKS AND SCENARIOS

Tasks

1. The tasks are classified into five general categories: Air, Surface, Subsurface, Mines, and Shore. Table A1 gives a summary of the list of tasks.

TABLE A1

FRIGATE TASK LIST

Air	**Surface**
Detect/track aircraft, ASMs	Detect/Track surface vessels
Identify aircraft, ASMs	Classify/Identify surface vessels
Counter/destroy aircraft, ASMs	Destroy surface vessels
Subsurface	**Mines**
Detect/classify submarines	Detect mines
Localize/track submarines	**Shore**
Destroy submarines	Detect targets ashore
Counter underwater attack	Engage targets ashore

Scenarios

2. A set of eleven scenarios are used to represent the range of taskings for the Canadian Forces, as developed by DGSP.

- Scenario 1: A Search and Rescue operation involving a cruise liner afire 100 NM off coast.
- Scenario 2: Disaster relief in Canada resulting from an earthquake on the West coast.
- Scenario 3: International humanitarian assistance in Central Africa.
- Scenario 4: Countering smugglers off the coast of Canada.
- Scenario 5: Permissive evacuation of Canadians overseas due to internal conflict.
- Scenario 6: Peace support operations leading to the establishment of a naval embargo.
- Scenario 7: Aid to the Civil Power required due to a prolonged drought inside Canada inciting internal disputes centered on water rights.
- Scenario 8: Dispute over mineral deposits just outside the 200 NM limit.
- Scenario 9: Peace support operations. Conflict between two states has resulted in a UN decision to restore the ante bellum status quo.
- Scenario 10: Defence of Canadian/US territory. An aggressive nation is preparing for a possible strike against North American targets, necessitating the monitoring of continental approaches for threats.
- Scenario 11: Collective defence of a NATO nation after war breaks out over a disputed border.

3. A few of these scenarios do not involve naval resources, or are sufficiently similar to other scenarios from a naval standpoint, and hence are not considered for this study. Thus, scenarios 4, 6, 8, 9, 10, and 11 are used. However, for the sake of consistency, the numbering of the scenarios is unchanged from the original list.

ANNEX B
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SURVEY

1. The following is a copy of the survey which was distributed to experienced naval officers identified for participation in this study. The results returned from this study served as the initial input for the consensus building exercise.

Building a Consensus of Naval Task Importance

On the following pages is a brief description of six scenarios, and a list of tasks. Your job is to determine the relative importance of each task in relation to each scenario.

Place yourself 10 years in the future. You are responsible for modifications of the City class ships. You are reviewing a number of potential scenarios that the City class ships must be prepared to face. For each scenario you have asked yourself which of five major warfare areas should be the focus of equipment modifications. To prioritize these areas, you have decided to use the following comparison box. For each pair of areas, you are comparing the relative importance of upgrading your capability in one over the other. A scale from 1 to 9 is used, as follows:

1 - The task on top is absolutely more important than the one on the left
2 - The task on top is very strongly more important than the one on the left
3 - The task on top is strongly more important than the one on the left
4 - The task on top is weakly more important than the one on the left
5 - The two tasks are equally important
6 - The task on the left is weakly more important than the one on top
7 - The task on the left is strongly more important than the one on top
8 - The task on the left is very strongly more important than the one on top
9 - The task on the left is absolutely more important than the one on top

	Air	Subsurface	Surface	Mines	Shore
Air	5				
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

However, upon further reflection, it is realized that most of the tasks given above can be broken down into sub-tasks, so each sub-task must also be rated using the same scale. For example, under air tasks, you have the following categories:

Air	Detect/Track	Identify	Counter/Destroy
Detect/Track	5		
Identify		5	
Counter/Destroy			5

As an example, consider the fictitious naval scenario of clearing the Rideau Canal of enemy threats, including submarines and mines. The first step is to complete the box of major warfare areas:

	Air	Subsurface	Surface	Mines	Shore
Air	5				
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

The first pair is air/subsurface. For this pairing, you may consider subsurface to be strongly more important than air. Using the given scale, the number 3 would be placed in the first box. The next comparison is air/surface, for which surface is weakly more important than air. The number 6 would be placed in this box. The next comparison is air/mines. Mines is considered very strongly more important, so the number 2 is inserted here. For the next comparison, air is considered strongly more important than shore, so the number 7 is inserted here. After the first set of comparisons, the matrix appears as follows:

	Air	Subsurface	Surface	Mines	Shore
Air	5	3	6	2	7
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

The remaining comparisons in the matrix are made in the same manner. Once this matrix is filled out, the remaining matrices are completed in the same manner.

Directions

For each of the six scenarios that follow, fill in the comparison boxes using the following scale

1 - The task on top is absolutely more important than the one on the left
2 - The task on top is very strongly more important than the one on the left
3 - The task on top is strongly more important than the one on the left
4 - The task on top is weakly more important than the one on the left
5 - The two tasks are equally important
6 - The task on the left is weakly more important than the one on top
7 - The task on the left is strongly more important than the one on top
8 - The task on the left is very strongly more important than the one on top
9 - The task on the left is absolutely more important than the one on top

There is a brief description provided of each scenario. You are free to make any further assumptions that you feel are required to properly complete the survey. These should be recorded in the *Comments* area of the survey.

When considering each warfare area, the following aspects of each should be considered:

Air:	Detect and track aircraft and anti-ship missiles
	Identify aircraft and anti-ship missiles
	Counter or destroy aircraft and anti-ship missiles
Subsurface:	Detect and classify submarines
	Localize and track submarines
	Destroy submarines
	Counter underwater attack

Surface:	Detect and track surface vessels
	Classify and identify surface vessels
	Destroy surface vessels
Mines:	Detect mines
Shore:	Detect targets ashore
	Engage targets ashore

Scenario 4: Countering smugglers off the coast of Canada.

Situation: Incidents of drug smuggling and landings of illegal immigrants on both East and West coasts have resulted in calls for the Canadian Government to "do something". The Government has directed that government agencies cooperate to stem the tide of illegal activities, to the extent that platforms of interest carrying such cargoes can be identified, tracked, and, if necessary or required by law enforcement agencies, intercepted before reaching Canadian territory.

Physical Environment: Canadian territory, and the air and sea approaches to Canada.

Military Environment:

a. Threat Information. The overall threat environment is very low. The targets of the operation are independent surface vessels or small aircraft seeking to avoid interception and effect covert transit to a Canadian destination. It is considered likely that the platforms will be equipped with technically sophisticated equipment (ESM, ECM) and armed with small arms.

b. Mission. Canadian Forces are to co-operate with the appropriate OGDs (RCMP, Customs, Immigration) to conduct covert surveillance of appropriate approaches to Canada and identify platforms of interest. If necessary, the CF should be prepared to intercept them prior to reaching Canadian territory.

c. Mission Success Criteria:

(1) Ability to detect and identify platforms of interest.
(2) Ability to track platforms of interest.
(3) Ability to respond to situation (intercept, board surface vessels/force landing of small aircraft) as per requests from OGDs.
(4) Ability to meet timing criteria.

d. Partial Listing of Tasks involved in the Accomplishment of the Mission:

(1) Contribute to threat assessment.
(2) Contribute to surveillance of Canadian approaches.
(3) Contribute to C2 process as requested.
(4) Contribute to tracking of platforms of interest.
(5) Be prepared to intercept and board/force landing of platforms of interest.

Scenario 4: Countering smugglers off the coast of Canada.

	Air	Subsurface	Surface	Mines	Shore
Air	5				
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

Air	Detect/Track	Identify	Counter/Destroy
Detect/Track	5		
Identify		5	
Counter/Destroy			5

Subsurface	Detect/Classify	Localize/Track	Destroy	Counter
Detect/Classify	5			
Localize/Track		5		
Destroy			5	
Counter				5

Surface	Detect/Track	Identify	Destroy
Detect/Track	5		
Identify		5	
Destroy			5

Shore	Detect	Engage
Detect	5	
Engage		5

Comments:

Scenario 6: Peace support operations leading to the establishment of a naval embargo.

Situation: Tension between two bordering states escalated until actual conflict broke out. After a series of quick successes and setbacks on both sides, the situation evolved into a prolonged stalemate. Both parties agreed to a UN-brokered cease-fire, Non-Governmental Organizations (NGOs) have deployed into the area, and it has been decided to establish a Canadian-led UN force under Chapter 6 of the UN Charter to conduct peacekeeping operations along the border area, as well as enforce a naval embargo and a no-flight zone.

Physical Environment: The two countries involved are part of a large island. The physical environment encountered would include terrain from both coastal regions and inland, urban and rural.

Military Environment:

a. Threat Information. The overall threat environment is low. UN Forces are being formed at the request of the two states previously involved in the conflict. The cease-fire is holding at the current time.

b. Mission. As part of a UN Peacekeeping Force, elements of the CF are to lead the UN Force and conduct peacekeeping operations under the auspices of Chapter 6 of the UN Charter.

c. Mission Success Criteria:
   (1) Ability to field mission-mandated forces and capabilities
   (2) Ability to meet mission-deployment time lines
   (3) Achievement of the Canadian-specific component of the mission
   (4) Sustainment of the CF response for the required duration

d. Partial Listing of Tasks involved in the Accomplishment of the Mission:
   (1) Deployment of CF assets to area of operations
   (2) Employment of Canadian Forces in peacekeeping duties
   (3) Employment of Air Forces in enforcement of no flight zones (as appropriate)
   (4) Employment of Naval Forces in enforcement of naval embargo (as appropriate)
   (5) Sustainment operations
   (6) Redeployment of CF elements

Scenario 6: Peace support operations leading to the establishment of a naval embargo.

	Air	Subsurface	Surface	Mines	Shore
Air	5				
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

Air	Detect/Track	Identify	Counter/Destroy
Detect/Track	5		
Identify		5	
Counter/Destroy			5

Subsurface	Detect/Classify	Localize/Track	Destroy	Counter
Detect/Classify	5			
Localize/Track		5		
Destroy			5	
Counter				5

Surface	Detect/Track	Identify	Destroy
Detect/Track	5		
Identify		5	
Destroy			5

Shore	Detect	Engage
Detect	5	
Engage		5

Comments:

Scenario 8: Dispute over mineral deposits just outside the 200 NM limit.

Situation: Discovery of highly concentrated deposits of gold, copper and zinc in commercially exploitable quantities on the seabed close to the 200 NM limit of Canada's coast have led to a dispute over seabed rights. Canadian claims for extended jurisdiction under UNCLOS III have been rejected by a certain country, and deep seabed exploitation vessels from that country have begun just beyond the 200 NM limit resulting in increased friction. Coast Guard vessels sent to warn these vessels off were turned back by small arms fire. Subsequently the country dispatched a frigate to protect her claims to these seabed resources, and rejected Canadian calls for a cessation of seabed operations until the case had been resolved by international arbitration, labelling such action as simple obstructionism.

Physical Environment: An offshore area which Canada is claiming jurisdiction over.

Military Environment:

a. Threat Information. Previous to the dispute the threat environment was very low. As the dispute continues an escalation up to moderate intensity can be considered.

b. Mission. The CF are to enforce Canadian claims in the extended Economic Exclusive Zone by supporting Coast Guard operations aimed at halting the other country's deep seabed operations. If hostile operations are encountered, the CF will be required to conduct sea control operations in order to achieve the Canadian national objective of asserting sovereignty over the seabed resources in dispute.

c. Mission Success Criteria:
   (1) Ability to provide combat capable forces in a timely manner.
   (2) Ability to stop the other country from mining (i.e. enforce Canadian claims).

d. Partial Listing of Tasks involved in the Accomplishment of the Mission:
   (1) Contribute to threat assessment.
   (2) Contribute to surveillance of the area of dispute.
   (3) Contribute to the C2 picture/process.
   (4) Use of combat capable forces as required.

Scenario 8: Dispute over mineral deposits just outside the 200 NM limit.

	Air	Subsurface	Surface	Mines	Shore
Air	5				
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

Air	Detect/Track	Identify	Counter/Destroy
Detect/Track	5		
Identify		5	
Counter/Destroy			5

Subsurface	Detect/Classify	Localize/Track	Destroy	Counter
Detect/Classify	5			
Localize/Track		5		
Destroy			5	
Counter				5

Surface	Detect/Track	Identify	Destroy
Detect/Track	5		
Identify		5	
Destroy			5

Shore	Detect	Engage
Detect	5	
Engage		5

Comments:

Scenario 9: Peace support operations.

Situation: Tension between two bordering states has escalated until intense armed conflict broke out. One state is about to attain an overwhelming victory over its opponent. It has been assessed by the international community that this would be unacceptable. This led to a decision in the UN to restore the previous situation, and resulted in an international force being formed. A coalition force is being established under the auspices of Chapter 7 of the UN Charter.

Physical Environment: The physical environment encountered would include terrain from both coastal regions and inland, urban and rural, with the dominant inland terrain being desert.

Military Environment:

a. Threat Information. Enemy forces to be faced will include a full range of combat capability, with modern tactical doctrine and current generation equipment for its land, naval and air forces. Enemy C4I assets are assessed to be state-of-the-art. Use of NBC weapons against coalition forces is assessed as being unlikely, but can not be completely discounted.

b. Mission. As part of a coalition of like-minded nations formed under the auspices of Chapter 7 of the UN Charter, elements of the CF are to conduct operations to restore the pre-conflict boundaries.

c. Mission Success Criteria:
   (1) Ability to field mission-mandated forces and capabilities
   (2) Ability to meet mission-deployment time lines
   (3) Achievement of the Canadian-specific component of the mission
   (4) Sustainment of the CF response for required duration

d. Partial Listing of Tasks involved in the Accomplishment of the Mission:
   (1) Operations to secure Coalition Force launching point (as appropriate)
   (2) Deployment of CF assets to area of operations
   (3) Employment of CF in operations
   (4) Employment of Air Forces in enforcement of no flight zones (as appropriate)
   (5) Employment of Naval Forces in enforcement of naval embargo (as appropriate)
   (6) Sustainment operations
   (7) Redeployment of CF elements

Scenario 9: Peace support operations.

	Air	Subsurface	Surface	Mines	Shore
Air	5				
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

Air	Detect/Track	Identify	Counter/Destroy
Detect/Track	5		
Identify		5	
Counter/Destroy			5

Subsurface	Detect/Classify	Localize/Track	Destroy	Counter
Detect/Classify	5			
Localize/Track		5		
Destroy			5	
Counter				5

Surface	Detect/Track	Identify	Destroy
Detect/Track	5		
Identify		5	
Destroy			5

Shore	Detect	Engage
Detect	5	
Engage		5

Comments:

Scenario 10: Defence of Canadian/US territory.

Situation: Canada, along with the United States, is participating in a coalition operation to restore the territorial integrity of an invaded nation. Intelligence assessments have determined that the aggressor nation may undertake threatening action against Canada and/or the US to foster national support and to demonstrate its military might and the vulnerability of the North American coalition partners.

Physical Environment: The air and sea approaches to North America.

Military Environment:

a. Threat Information. The aggressor controls an effective military force that is capable of carrying out an attack on North America. The aggressor possesses nuclear and chemical weapons and delivery platforms. An attack could range from instigating or funding internal discontent to repeated covert incursions into sovereign territory by aircraft, surface and/or sub-surface vessels.

b. Mission. Timely threat warning and accurate attack assessment must be provided. In cooperation with US military forces, CF would conduct surveillance of air and maritime approaches to North America. The CF would attempt to detect, identify, and intercept the hostile vessel/aircraft before it arrives within attack range of North America. Land Forces would provide land surveillance and vital point protection.

c. Mission Success Criteria. Timely threat warning and accurate attack assessment to permit the effective use of forces. Detection, identification and interception of the hostile vessel/force before it is able to conduct the attack.

d. Partial Listing of Tasks involved in the Accomplishment of the Mission:
   (1) Surveillance, identification and intercept.
   (2) Land surveillance and protection of Vital Points.
   (3) Naval Mine/EOD clearance operations.

Scenario 10: Defence of Canadian/US territory.

	Air	Subsurface	Surface	Mines	Shore
Air	5				
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

Air	Detect/Track	Identify	Counter/Destroy
Detect/Track	5		
Identify		5	
Counter/Destroy			5

Subsurface	Detect/Classify	Localize/Track	Destroy	Counter
Detect/Classify	5			
Localize/Track		5		
Destroy			5	
Counter				5

Surface	Detect/Track	Identify	Destroy
Detect/Track	5		
Identify		5	
Destroy			5

Shore	Detect	Engage
Detect	5	
Engage		5

Comments:

Scenario 11: Collective defence of a NATO nation.

Situation:

a. A NATO nation and its neighbour have a long-standing dispute over a border. Although there is an extensive history surrounding the border dispute, the current borders, with the disputed territory within the boundary of the NATO nation, have been recognized by the international community. A recent natural resources discovery within the area has rekindled the dispute.

b. With a faltering economy, growing national debt, and diminishing standard of living, the neighbouring nation has resurrected territorial claims for lands adjacent to the disputed border. This led to increased tension, until the neighbouring nation invaded the disputed area. The invading armed forces established control over significant territory before being halted, and both armed forces have now adopted hasty defensive postures.

Physical Environment: The land mass involved includes a wide variety of terrain types, including plains, highlands, mountains, coastal areas and urban centres. Both countries possess a coastline with deep water approaches and several port facilities.

Military Environment:

a. Threat Information. The enemy forces include a full range of combat capability, with modern tactical doctrine and current generation equipment for its land, naval and air forces. Enemy C4I assets are assessed to be state-of-the-art. Use of NBC weapons against NATO forces is assessed as being unlikely, but cannot be completely discounted.

b. Mission. The CF, as part of the NATO forces, will conduct operations to restore and return control of the invaded territory, waters and airspace to the NATO nation.

c. Mission Success Criteria:

(1) Ability to field mission-mandated forces and capabilities
(2) Ability to meet mission-deployment time lines
(3) Achievement of the Canadian-specific component of the mission
(4) Sustainability of the CF response for the required duration

d. Partial Listing of Tasks involved in the Accomplishment of the Mission:

(1) Deploy forces to theatre.
(2) Secure the rear area for the assembly and deployment of NATO forces.
(3) Defend territory not yet occupied by the invading nation.
(4) Eject enemy forces from invaded territory.
(5) Establish a buffer zone along the internationally recognized border.
(6) Assist in the restoration of civil authority in the occupied territory.
(7) Sustain forces as long as required.

Scenario 11: Collective defence of a NATO nation.

	Air	Subsurface	Surface	Mines	Shore
Air	5				
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

Air	Detect/Track	Identify	Counter/Destroy
Detect/Track	5		
Identify		5	
Counter/Destroy			5

Subsurface	Detect/Classify	Localize/Track	Destroy	Counter
Detect/Classify	5			
Localize/Track		5		
Destroy			5	
Counter				5

Surface	Detect/Track	Identify	Destroy
Detect/Track	5		
Identify		5	
Destroy			5

Shore	Detect	Engage
Detect	5	
Engage		5

Comments:

ANNEX C
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MARCH 1998

MATHEMATICAL CALCULATIONS

Gathering A Consensus

1. In the initial survey, the participants are asked to judge each pair of tasks, and assign a number between one and nine to describe the pairwise relationship. For instance, using the matrix below, the first comparison would be between air and subsurface tasks, then air and surface tasks, and so on.

	Air	Subsurface	Surface	Mines	Shore
Air	5				
Subsurface		5			
Surface			5		
Mines				5	
Shore					5

If the chart above is considered as a matrix, with A_{ij} representing the number at the ith row and jth column, then the matrix B is constructed in the following manner. For B_{ij} where i is less than or equal to j:

$$B_{ij}=\begin{cases} 2A_{ij}-9 & \text{if } A_{ij}\geq 5 \\ \dfrac{1}{-2A_{ij}+11} & \text{otherwise} \end{cases} \qquad (1)$$

If i is greater than j, then:

$$B_{ij}=\frac{1}{B_{ji}} \qquad (2)$$

2. Using the resultant matrix B, the weighting is then equal to the normalized eigenvector corresponding to the maximum eigenvalue of B. This is calculated by successively squaring B to create the sequence of matrices B, B^2, B^4, B^8, etc. For each matrix in this sequence, compute the

sum of each row, and normalize the resulting vector. This sequence of vectors will converge to the desired weighting.

3. For example, suppose A is equal to:

	Air	Subsurface	Surface	Mines	Shore
Air	5	8	4	9	9
Subsurface		5	3	1	1
Surface			5	9	9
Mines				5	1
Shore					5

The matrix B and the normalized row sum is equal to:

$$\begin{bmatrix} 1 & 7 & 0.33 & 9 & 9 \\ 0.14 & 1 & 0.2 & 0.11 & 0.11 \\ 3 & 5 & 1 & 9 & 9 \\ 0.11 & 9 & 0.11 & 1 & 0.11 \\ 0.11 & 9 & 0.11 & 9 & 1 \end{bmatrix} \quad \begin{bmatrix} 0.31 \\ 0.02 \\ 0.32 \\ 0.12 \\ 0.23 \end{bmatrix} \tag{3}$$

Squaring B gives the following matrix and normalized row sum:

$$\begin{bmatrix} 5 & 177.66 & 4.07 & 102.78 & 22.78 \\ 0.91 & 5 & 0.47 & 4.31 & 3.32 \\ 8.71 & 193 & 5 & 126.56 & 46.56 \\ 1.85 & 20.33 & 2.07 & 5 & 3.22 \\ 2.84 & 100.33 & 3.06 & 21 & 5 \end{bmatrix} \quad \begin{bmatrix} 0.36 \\ 0.02 \\ 0.44 \\ 0.07 \\ 0.15 \end{bmatrix} \tag{4}$$

Repeating the process three more times gives the following normalized row sums (the squared matrices are not given):

$$\begin{bmatrix}0.32\\0.03\\0.47\\0.06\\0.13\end{bmatrix} \quad \begin{bmatrix}0.33\\0.03\\0.46\\0.05\\0.13\end{bmatrix} \quad \begin{bmatrix}0.33\\0.03\\0.46\\0.05\\0.13\end{bmatrix} \tag{5}$$

On the final iteration, all of the values are within 0.01 of the previous iteration, so the process is halted. This final vector gives the desired weights.

ANNEX D
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Abbreviations

1. This section lists the various abbreviations used to describe the equipment upgrade options which are being considered in the FELEX project.

a. CIWS. Close In Weapons System.

b. CIWS (RAM). Close In Weapons System Rolling Airframe Missile.

c. ESSM. Evolved Sea Sparrow Missile.

d. AAW. Anti-Air Warfare.

e. PGM. Precision Guided Munitions.

f. STIR. Search Track Infra Red.

g. APAR. Advanced Phased Array Radar.

h. NULKA. A brand name for an electronic warfare decoy.

i. SIERA. Ships Integrated Electronic Warfare Replacement Activity.

j. ELINT. Electronic Intelligence.

k. SIRIUS. A product name for an InfraRed Search and Track/ Detection (IRSTD) system.

l. CEC. Cooperative Engagement Capability.

m. HFSWR. High Frequency Surface Wave Radar.

n. IASWSS. Integrated Anti Submarine Warfare Sonar Suite.

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Canada's Maritime Forces are pursuing a Frigate Equipment Life Extension (FELEX) program, the intent of which is to maintain the capabilities of the City class frigates in the face of advancing threat technology. Maritime Operational Research was tasked to assist in deciding which potential upgrades should be pursued. A survey was conducted among senior naval officers to determine the relative priorities of upgrading ship capability in various warfare areas. Through the survey, it was determined that Air and Surface warfare capability have the highest upgrade priority, followed by Subsurface capability. Ship capability in the Mine and Shore warfare areas were given a much lower priority.

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FELEX

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EQUIPMENT

CITY CLASS

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